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FOSSIL DIATOMS FROM
SOUTHERN BAJA CALIFORNIA

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In April, 1965, Mr. Victor J. Bergeron of San Francisco put his airplane and pilot, Edward Osborn, at the disposal of a party from the California Academy of Sciences to investigate a deposit of fossils in southern Baja California, Mexico. Some bones and shells from the locality had attracted Mr. Bergeron's attention on an earlier visit. The field party consisted of Drs. George E. Lindsay, J. Wyatt Durham, Robert T. Orr, Harry ("Bing") Crosby, and the senior author of the present article. Mr. Crosby knew the country well from previous visits and acted as guide along with Sr. Cesar Osuna Peralta, Mayor of Santiago. The nearest landing field to the fossil-bearing deposits at Rancho El Refugio was at Santiago. This Rancho is about 15 kilometers south.

On the way back to Santiago from there, some exposures on the right-hand side of the road, about eight kilometers south of Santiago, attracted attention. Upon hand lens inspection it was at once obvious that the fine

grained pale buff shales contained considerable numbers of fossil diatoms and it is upon these that the present paper is based.

The mollusks at Rancho El Refugio occur in sands and silts believed to be Pliocene in age. The diatom-bearing marine shales, however, are Miocene, believed to be approximately equivalent in age to the late part of that period, known as the Delmontian stage in California. The nearest equivalent strata known in Mexico are the diatomites exposed in Arroyo Hondo, Maria Madre Island of the Tres Marias group (Hanna, 1926). There are some diatom-bearing shales near Purissima, Baja California, but it is believed from the meager evidence available that they are considerably older.

A general account of the trip to Santiago has been published by Dr. Lindsay (1965).

***Actinoptychus splendens* (Shadbolt).**

(Figures 1, 4.)

Actinophaenia splendens SHADBOLT, 1854. Trans. Micr. Soc. London, n.s., vol. 2, p. 16.

Actinoptychus splendens (Shadbolt), RALFS in Pritchard, 1861, p. 840. SCHMIDT, Atlas Diat., pl. 153, 1890, figs. 3, 15, 16. HUSTEDT, Kieselalgen, vol. 7, pt. 3, 1929, p. 478, fig. 265.

Shadbolt's name seems to be the first of a long series which have been assigned to various forms of this extremely variable species. It is a widespread living form (if the interpretation be a broad one) and is also abundant in most marine Miocene deposits of fossil diatoms.

***Actinoptychus gruendleri* Schmidt.**

(Figures 2, 3, 5.)

Actinoptychus gruendleri SCHMIDT, Atlas Diat., pl. 1, 1874, fig. 22. "Monterey."
[Miocene.]

Actinoptychus stella SCHMIDT, Atlas Diat., pl. 90, 1886, figs. 1, 2; pl. 132, 1888, fig. 23.

Actinoptychus gallegosi HANNA AND GRANT, 1926. Proc. Calif. Acad. Sci., ser. 4, no. 2, p. 120, pl. 11, fig. 6. Maria Madre Island, Mexico.

Many specific and varietal names have been given to the various forms this plastic species has taken during past geologic periods. Some of these names have acquired wide usage in diatom literature. *Actinoptychus gruendleri* seems to have been the earliest and it has page priority over any of the others illustrated by Schmidt. Most of the names can be found in Mill's Index to the genera and species of Diatomaceae, but in the early history of the subject, there is confusion due to the idea that species could be separated on the basis of the number of sectors into which the disk is divided.

The illustration on plate 132 (fig. 23) of the Atlas was stated by Schmidt: "probably to be attached to *A. stella* A. S. Grunow determined this

form as *A. moronensis* (Grev.) Grunow var."¹ *Omphalopelta moronensis* was described in 1866 by Greville (p. 122), and if Grunow was correct, this name must replace *A. gruendleri* and many others. A comparison of Greville's figure of "*A. moronensis*" is not entirely convincing, and we do not have any material available from Moron. Perhaps if Greville's slide is still intact, this group of diatoms can be put in better order. His drawing is not very satisfactory and he commented on the difficulty in showing the sculpture correctly. Azpeitia (Diat. Española, 1911), in his extended work on diatoms of Spanish deposits, listed both *A. gruendleri* and *A. moronensis* from Moron thus implying that the two species may be separately recognized.

Greville stated that his "*A. moronensis*" might be compared to *Omphalopelta versicolor* Ehrenberg (1844, p. 270), an unfigured species, which Mills (Index, Diat., 1934, p. 1255) considered to be equivalent to "*Actinoptychus gruendleri*." In our opinion *Omphalopelta versicolor* is a *nomen nudum*.

The specimen shown in our figure 5 has a very wide border zone marked with fine decussating lines of dots. This has not been seen by us before and may represent some one of the named forms of *A. gruendleri* or perhaps an unnamed one.

Stictodiscus hardmanianus Greville.

(Figure 6.)

Stictodiscus hardmanianus GREVILLE, 1865. Trans. Micr. Soc. London, n.s., vol. 13, p. 98, pl. 8, fig. 4. SCHMIDT, Atlas Diat., 1882, pl. 74, fig. 8.

The frustules of this species are much more delicate than those of *Stictodiscus californicus*. This feature is not evident in illustrations and therefore there may be confusion in some cases. Mills (Index, Diat. 1935, p. 1496) questioned the 1927 illustration of the upper Eocene diatom, which one of us studied (Hanna, 1927, p. 121).

Coscinodiscus radiatus Ehrenberg.

(Figure 7.)

Coscinodiscus radiatus EHRENBURG, Abh. Akad. Wiss. Berlin, 1839, p. 148. EHRENBURG, Mikrog. 1854, pl. 35A, 17, fig. 6; pl. 39, 3, fig. 17.

Diatoms of this general form are often referred to *Coscinodiscus radiatus*. There are numerous other names of later date available; however, most of these differ by minor variation. Specimens are very common in the Baja California material.

¹ E. V. Preston, Explanatory Comments on A. Schmidt's Atlas of the Science of Diatoms. Translated from the German. [Unpublished manuscript in the library of the California Academy of Sciences, extending to plate 152.]

Coscinodiscus floridulus Schmidt.

(Figure 8.)

Coscinodiscus floridulus SCHMIDT, Atlas Diat., pl. 113, 1888, fig. 16. "Santa Monica." California.

The specimens from Santiago, Baja California, agree in most details with the original figure. Schmidt's figure and his material came from the old collection with the locality "Santa Monica." It now seems certain that material actually came from a short distance southeast of Redondo, California, the age of which is upper Miocene, the Delmontian stage of students of Foraminifera.

Coscinodiscus kurzii Grunow.

(Figure 9.)

Coscinodiscus kurzii GRUNOW in Schmidt, Atlas Diat., pl. 113, 1888, fig. 17. LOHMAN, 1938, U.S. Geol. Surv. Prof. Ppr. 189C, pl. 20, fig. 1; pl. 21, fig. 2. Kettleman Hills, California. Pliocene.

The specimens we have examined agree almost entirely with the original figure in Schmidt's Atlas, even to the enlarged areolae in the center. The original locality is given simply as "Elephant Point," which Schmidt identified at times elsewhere in the Atlas as being in "Bengal."

Coscinodiscus lineatus Ehrenberg.

(Figures 10, 11.)

Coscinodiscus lineatus EHRENBURG, 1838. Abh. Akad. Wiss. Berlin, p. 129 [1840]. EHRENBURG, Mikrog. 1854, pl. 18, fig. 33; pl. 22, fig. 6a-b; pl. 35A, group 16, fig. 7. SCHMIDT, Atlas Diat., 1874, pl. 1, figs. 26-32. WOLLE, Diat. N. Amer. 1894, pl. 87, fig. 10. HANNA AND GRANT, 1926. Proc. Calif. Acad. Sci., ser. 4, vol. 15, no. 2, p. 139, pl. 15, fig. 6. Maria Madre Island, Mexico.

FIGURE 1. *Actinoptychus splendens* Shadboldt. Hypotype no. 3657 (CAS). Diameter, 0.1240 mm.

FIGURE 2. *Actinoptychus gruendleri* Schmidt. Hypotype no. 3658 (CAS). Diameter 0.160 mm.

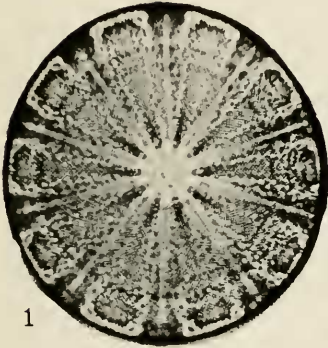
FIGURE 3. *Actinoptychus gruendleri* Schmidt. Hypotype no. 3659 (CAS). Diameter 0.1696 mm.

FIGURE 4. *Actinoptychus splendens* Shadboldt. Hypotype no. 3660 (CAS). Diameter 0.10 mm.

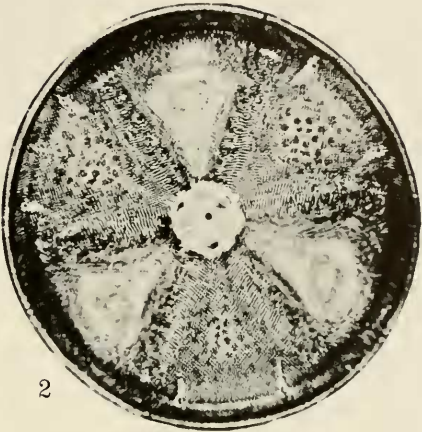
FIGURE 5. *Actinoptychus gruendleri* Schmidt. Hypotype no. 3661 (CAS). Diameter, 0.1512 mm.

FIGURE 6. *Stictodiscus hardmanianus* Greville. Hypotype no. 3662 (CAS). Diameter 0.0572 mm.

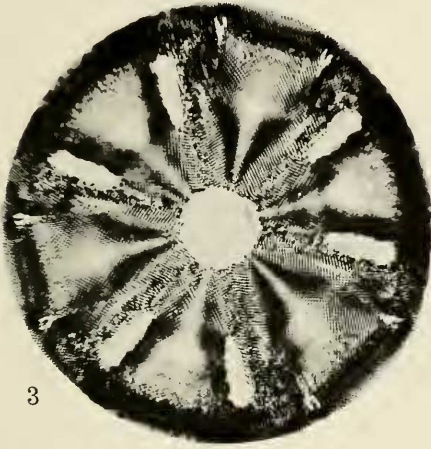
Specimens represented by figures 1-6 are from locality no. 39301 (CAS), eight kilometers south of Santiago, Baja California, and are deposited in the type collection of the Department of Geology of the California Academy of Sciences.



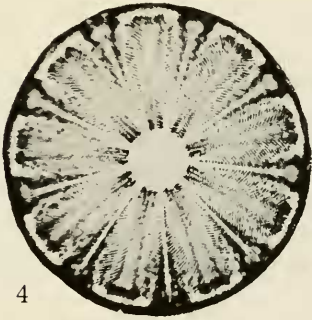
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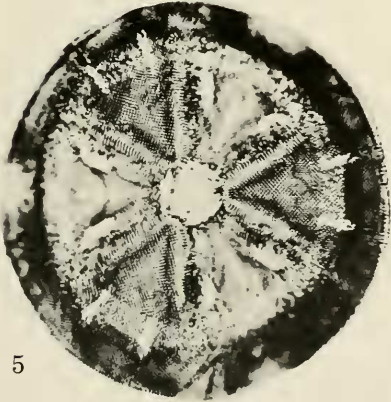
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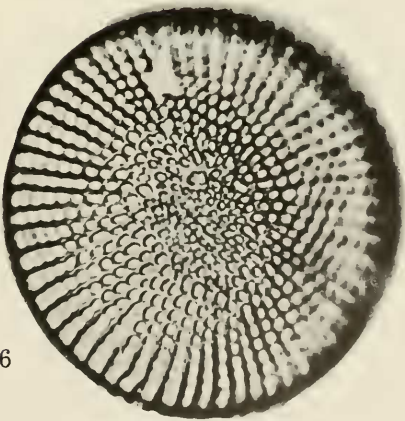
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6

This very common species is readily recognized by the regular spacing of the surface markings in a 60-degree pattern. There is much variation, especially in the border where there may actually be a series of very low projections. A form usually put in another genus has actual spines on the margin and also on the surface of the disk.

***Coscinodiscus evermanni* Hanna and Grant.**

(Figures 12, 13.)

Coscinodiscus evermanni HANNA AND GRANT, 1926. Proc. Calif. Acad. Sci., ser. 4, vol. 15, no. 2, p. 137, pl. 15, fig. 3. Maria Madre Island, Mexico.

The sharply raised zone near the border sets this diatom apart from any other which we have found in the literature. The nearest one it seems to resemble is *Craspedodiscus klavsdanii* Gruendler (Schmidt Atlas Diat., pl. 184, 1893, fig. 5, "Mors.") which, however, has much finer areolae. The structure of the diatom is best shown in a cross section such as that given in the Maria Madre Island paper cited above.

***Stictodiscus californicus* Greville.**

(Figures 14, 16.)

Stictodiscus californicus GREVILLE, 1861. Trans. Micr. Soc. London, n.s., vol. 9, p. 79, pl. 10, fig. 1, Monterey, fossil. SCHMIDT, Atlas Diat., pl. 74, 1882, figs. 4, 5. HANNA AND GRANT, 1926. Proc. Calif. Acad. Sci., ser. 4, vol. 15, no. 2, p. 167, pl. 20, fig. 12. Maria Madre Island, Mexico. LINDSAY, Pacific Discovery, vol. 18, no. 6, 1965, p. 22.

The species is common in many California deposits of upper Miocene age and was abundant in the heavy fraction of the Santiago, Baja California collection.

FIGURE 7. *Coscinodiscus radiatus* Ehrenberg. Hypotype no. 3663 (CAS). Diameter, 0.1452 mm.

FIGURE 8. *Coscinodiscus kurzii* Grunow. Hypotype no. 3664 (CAS). Diameter, 0.1232 mm.

FIGURE 9. *Coscinodiscus floridulus* Schmidt. Hypotype no. 3665 (CAS). Diameter 0.1172 mm.

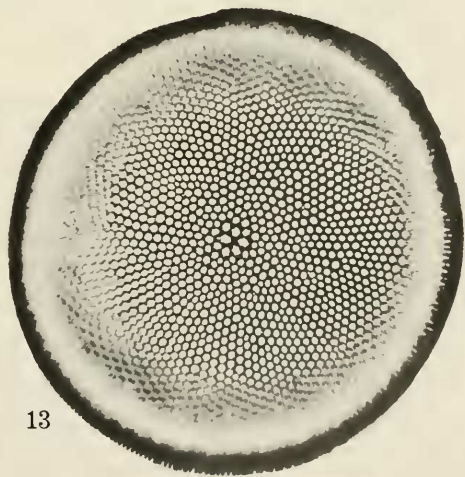
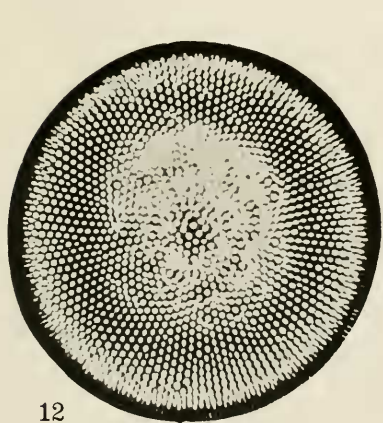
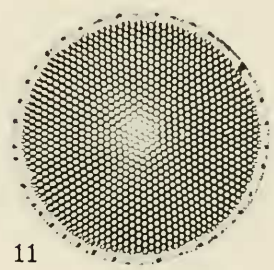
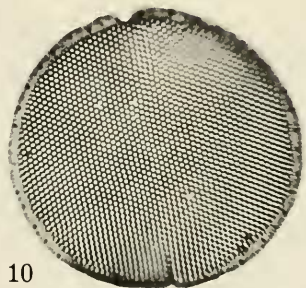
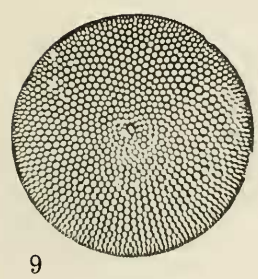
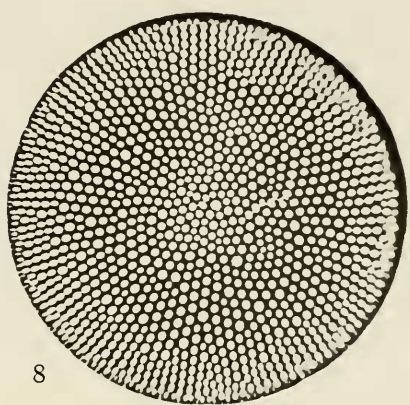
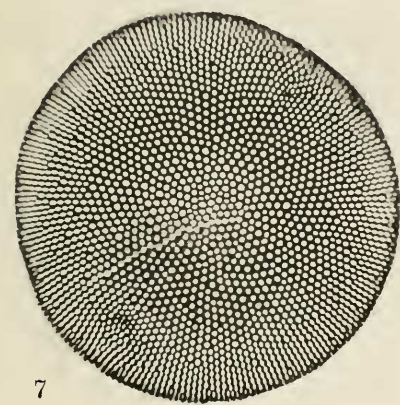
FIGURE 10. *Coscinodiscus lineatus* Ehrenberg. Hypotype no. 3666 (CAS). Diameter, 0.1068 mm.

FIGURE 11. *Coscinodiscus lineatus* Ehrenberg. Hypotype no. 3667 (CAS). Diameter, 0.0942 mm.

FIGURE 12. *Coscinodiscus evermanni* Hanna and Grant. Hypotype no. 3668 (CAS). Diameter, 0.1648 mm.

FIGURE 13. *Coscinodiscus evermanni* Hanna and Grant. Hypotype no. 3669 (CAS). Diameter 0.1704 mm.

Specimens represented by figures 7-13 are from locality no. 39301 (CAS), eight kilometers south of Santiago, Baja California, and are deposited in the type collection of the Department of Geology of the California Academy of Sciences.



Eupodiscus radiatus Bailey.

(Figures 15, 17.)

Eupodiscus radiatus Bailey, var. *antiquua* Cox, in Kain and Schultze, Bull. Torrey Bot. Club, vol. 16, no. 8, 1889, p. 209. WOLLE, Diat. N. Amer., 1894, pl. 77, fig. 8.

Eupodiscus antiquus Cox, HANNA, 1932. Proc. Calif. Acad. Sci., ser. 4, vol. 20, p. 190. Middle Miocene, Sharktooth Hill, California.

The difficulties inherent in the unscrambling of names in this group were pointed out to a certain extent in the Sharktooth Hill paper in 1932. The border zone in the material from there was much heavier than in the present specimens and as illustrated in most figures. However, this hardly seems to warrant separation at this time. As pointed out by Hendey (1954, p. 540, footnotes 1 and 2), the International Botanical Congress at Stockholm, July, 1952, p. 71, conserved the genus name *Eupodiscus* in the manner in which Rattray (Journ. Roy. Micr. Soc., 1888, p. 909) used it.

Auliscus sculptus (W. Smith).

(Figure 18.)

Eupodiscus sculptus W. SMITH, Syn. British Diat., vol. 1, 1853, p. 25, pl. 4, fig. 42.

Auliscus sculptus (W. Smith), RALFS in Pritchard, 1861, p. 845, pl. 6, fig. 3.

Auliscus coelatus BAILEY, 1854. Smithsonian Cont. Knowl., vol. 7, p. 6, pl. 1, figs. 3, 4. SCHMIDT, Atlas Diat., pl. 32, 1875, fig. 15. Monterey, fossil. HANNA AND GRANT, 1926. Proc. Calif. Acad. Sci., ser. 4, vol. 15, no. 2, p. 129, pl. 13, fig. 8. Maria Madre Island, Mexico.

FIGURE 14. *Stictodiscus californicus* Greville. Hypotype no. 3670 (CAS). Diameter, 0.1728 mm.

FIGURE 15. *Eupodiscus radiatus* Bailey. Hypotype no. 3671 (CAS). Diameter, 0.1424 mm.

FIGURE 16. *Stictodiscus californicus* Greville. Hypotype no. 3672 (CAS). Diameter, 0.1400 mm.

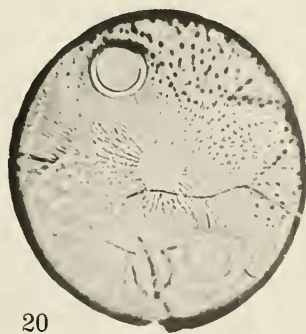
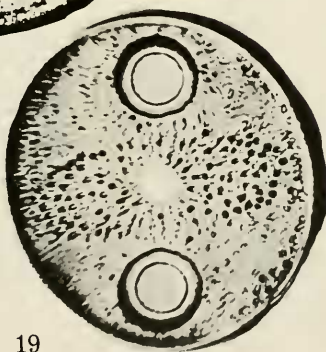
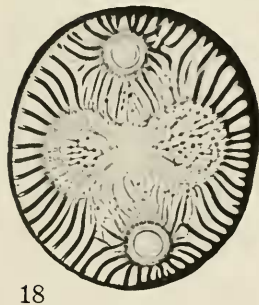
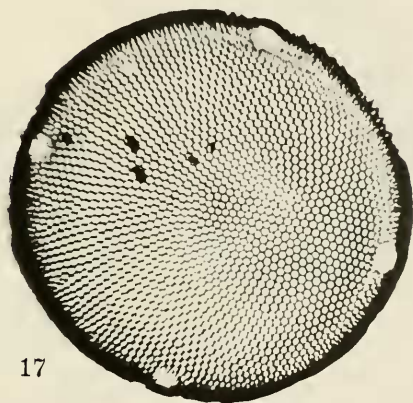
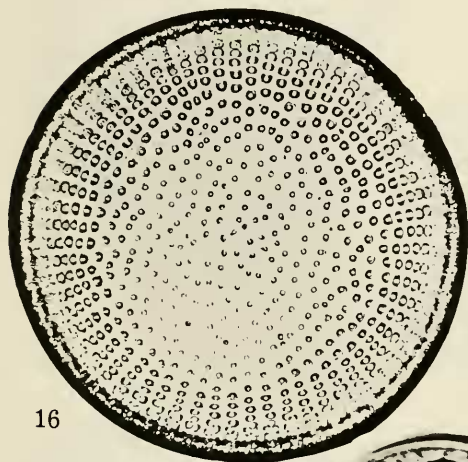
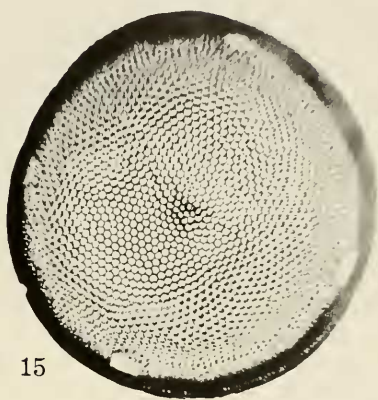
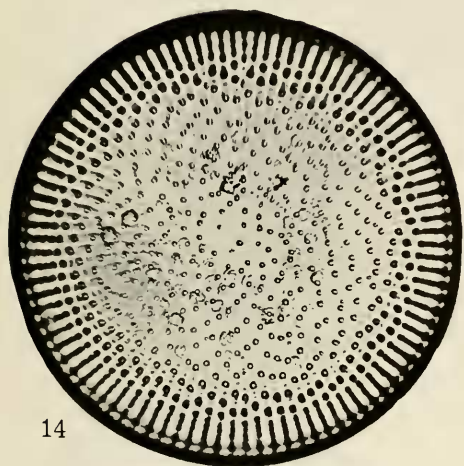
FIGURE 17. *Eupodiscus radiatus* Bailey. Hypotype no. 3673 (CAS). Diameter, 0.1488 mm.

FIGURE 18. *Auliscus sculptus* (W. Smith), Ralfs in Pritchard. Hypotype no. 3674 (CAS). Diameter, 0.0744 mm.

FIGURE 19. *Auliscus pruinus* Bailey. Hypotype no. 3675 (CAS). Diameter, 0.090 mm.

FIGURE 20. *Auliscus pruinus* Bailey. Hypotype no. 3676 (CAS). Diameter, 0.1164 mm.

Specimens represented by figures 14-20 are from locality no. 39301 (CAS), eight kilometers south of Santiago, Baja California, and are deposited in the type collection of the Department of Geology of the California Academy of Sciences.



Although there are many species of *Auliscus* in west American deposits of diatomite, this is one of the most distinct and least variable. There is much confusion among the records in the literature between diatoms identified as *A. coelatus* and those called *A. sculptus*. The latter was described in 1853 and therefore has priority over Bailey's name. Hendey (1964, pp. 98-99) pointed out that the two names apply to the same species after he had examined Bailey's type slide and we agree fully that the later name should be reduced to synonymy.

***Auliscus pruinus* Bailey.**

(Figures 19, 20.)

Auliscus pruinus BAILEY, 1854. Smithsonian Cont. Knowl., vol. 7, p. 5, pl. 1, figs. 5-8. SCHMIDT, Atlas Diat., pl. 31, 1875, figs. 6, 7, 11, 13-15; pl. 32, 1875, fig. 5, pl. 108, 1886, fig. 10. HANNA AND GRANT, 1926. Proc. Calif. Acad. Sci., ser. 4, vol. 15, p. 130, pl. 13, fig. 10. Maria Madre Island, Mexico.

This is a common species at the Santiago, Baja California, locality. It is found in many west American deposits of upper Miocene age.

***Aulacodiscus scaber* Ralfs.**

(Figure 21.)

Aulacodiscus scaber RALFS, in Pritchard, Infusoria, ed. 4, 1861, p. 844. SCHMIDT, Atlas Diat., pl. 33, 1876, figs. 4-8.

This diatom, and the two following, have been identified for us by Dr. Joseph Burke of Staten Island Museum. He has been engaged in a special

FIGURE 21. *Aulacodiscus scaber* Ralfs. Hypotype no. 3677 (CAS). Diameter, 0.1244 mm.

FIGURE 22. *Aulacodiscus thumii* Schmidt. Hypotype no. 3678 (CAS). Diameter, 0.1244 mm.

FIGURE 23. *Aulacodiscus margaritaceus* Bailey. Hypotype no. 3679 (CAS). 0.1488 mm.

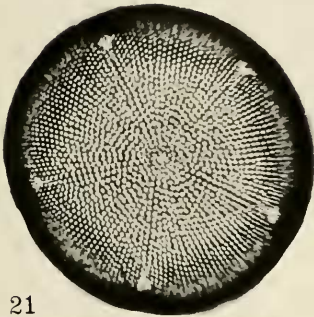
FIGURE 24. *Cerataulus imperator* Hanna and Grant. Hypotype no. 3680 (CAS). Major diameter, 0.1072 mm.; minor diameter, 0.100 mm.

FIGURE 25. *Surirella fastuosa* Ehrenberg. Hypotype no. 3681 (CAS). Major diameter, 0.1368 mm.; minor diameter, 0.1100 mm.

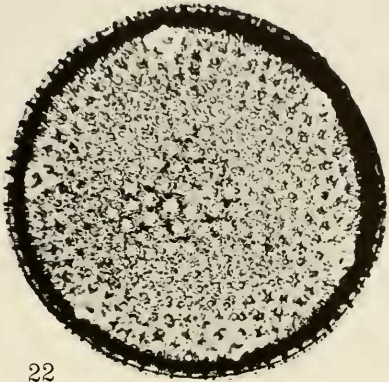
FIGURE 26. *Campylodiscus hodgsonii* W. Smith. Hypotype no. 3682 (CAS). Diameter, 0.140 mm.

FIGURE 27. *Campylodiscus kittonianus* Greville. Hypotype no. 3683 (CAS). Diameter, 0.0896 mm.

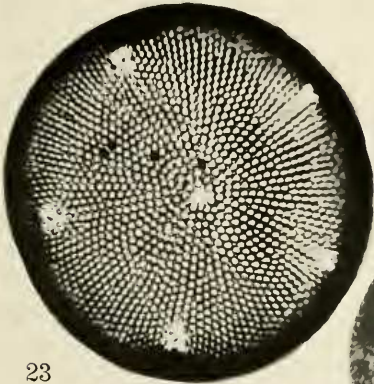
Specimens represented by figures 21-27 are from locality no. 39301 (CAS), eight kilometers south of Santiago, Baja California, and are deposited in the type collection of the Department of Geology of the California Academy of Sciences.



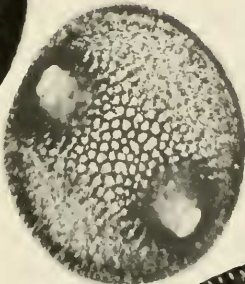
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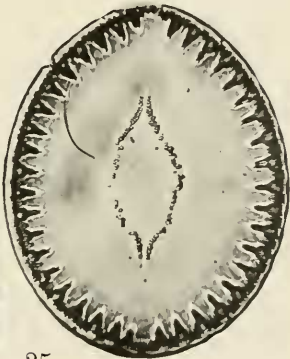
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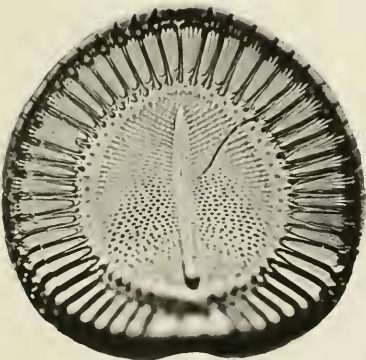
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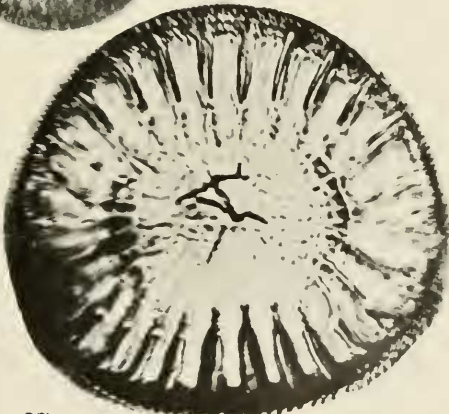
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study of the species of this genus for some time and it appears that when this is completed the group will not be so difficult to interpret as it has been in the past. The original specimens came from "Peruvian guano."

***Aulacodiscus thumii* Schmidt.**

(Figure 22.)

Aulacodiscus thumii SCHMIDT, Atlas Diat., pl. 102, 1886, fig. 8.

There is some confusion over the application of the genus name *Eupodiscus* to this and a few other species which are obviously not very different from *Aulacodiscus*. Boyer selected the species "*argus*" as the genotype of *Eupodiscus*, but Hendey (1964, p. 97) placed that species in *Aulacodiscus*. The problem is entangled by some early ill-defined names resulting in large part from imperfections in the optics of microscopes of that early era.

***Aulacodiscus margaritaceus* Ralfs.**

(Figure 23.)

Aulacodiscus margaritaceus RALFS in Pritchard, Infusoria, ed. 4, 1861, p. 844. SCHMIDT, Atlas Diat., pl. 37, 1876, figs. 1-8. "California."

Our specimens from Santiago, Baja California, agree very well with Ralfs' description and Schmidt's figures.

***Cerataulus imperator* Hanna and Grant.**

(Figure 24.)

Cerataulus imperator HANNA AND GRANT, 1926. Proc. Calif. Acad. Sci., ser. 4, vol. 15, no. 2, p. 134, pl. 14, fig. 9. Maria Madre Island, Mexico.

Diatoms of this genus are so convex and the processes are so high that they are very difficult to photograph. This present species has the surface markings heavier than most others. It has been referred to *C. ovalis* Schmidt (Atlas Diat., pl. 115, 1888, figs. 5-7) (by Mann in letter) but that is a much finer sculptured diatom and intergrading specimens have not been found thus far. It may be suspected that they do occur, because Schmidt's material was all recorded simply as from "Californien."

***Surirella fastuosa* Ehrenberg (?).**

(Figure 25.)

Surirella fastuosa EHRENBURG, Abh. Akad. Wiss. Berlin, 1840, p. 214 [Mills]. EHRENBURG, C. G., Verbreitung und Einfluss des mikroskopischen Lebens in Süd- und Nord-Amerika. Abh. Akad. Wiss. Berlin, 1841 [1843], pl. 4, fig. 7. [This publication is often cited in diatom literature simply as "Amer.".]

Most species of this genus are very attractive diatoms and this specimen, because of its simplicity, is especially so. However, if all of the pub-

lished figures which have been referred to it or some of its "varieties" then it is one of the most protean of diatoms. Our specimen differs from any of the illustrations we have seen in that the marginal bars are very short, and except for the central spindle-shaped row of small dots, there are no apparent surface markings.

This may be of sufficient difference to consider the only specimen we found in the Santiago material, a new species, but under the circumstances it seems best to defer such action until more evidence is available. The closest approach to any of the illustrations we have seen is that of Pantocsek (1893, pl. 38, fig. 530), which he named *Surirella subfastuosa*.

Campylodiscus hodgsonii W. Smith.

(Figure 26.)

Campylodiscus hodgsonii W. SMITH, 1853. Syn. British Diat., vol. 1, p. 29, pl. 6, fig. 53. SCHMIDT, Atlas Diat., pl. 53, 1877, fig. 5. WOLLE, Diat. N. Amer., 1894, pl. 70, fig. 3.

Campylodiscus imperialis GREVILLE, 1860. Trans. Micr. Soc. London, n.s., vol. 8, p. 30, pl. 1, fig. 3. SCHMIDT, Atlas Diat., pl. 17, 1875, fig. 20; pl. 52, 1877, fig. 7; pl. 53, 1877, figs. 6, 7. Campechy Bay, Mexico.

Only a few specimens of this beautiful diatom were found in the Santiago, Baja California, samples.

Campylodiscus kittonianus Greville.

(Figure 27.)

Campylodiscus kittonianus GREVILLE, Trans. Micr. Soc. London, vol. 8, n.s., 1860, p. 32, pl. 1, fig. 7. SCHMIDT, Atlas Diat., pl. 16, 1875, verb. ed. 1885, figs. 19, 20.

Our specimen from Santiago, Baja California, agrees very well with Schmidt's figures. His specimens were supposed to have come from Samoa and Brazil and presumably were not fossils.

Surirella patens Schmidt.

(Figures 28, 29.)

Surirella patens SCHMIDT, Atlas Diat., pl. 4, 1874 [ed. 2, 1885], figs. 16, 17; pl. 56, 1877 [ed. 2, 1886], figs. 10, 11. HANNA AND GRANT, Proc. Calif. Acad. Sci., ser. 4, vol. 15, no. 2, 1926, p. 168, pl. 21, fig. 2. "Maria Madre Island, Mexico" Upper Miocene.

This is one of the earliest names which we have found for a large group of supposed species separated by very minute differences. One of these is *S. hybrida* (Grunow in Van Heurck, Syn. Diat. Belgique, pl. 73, 1881, fig. 18; Schmidt, Atlas Diat., pl. 358, 1925, figs. 1-7), which Van Heurck stated was one of numerous forms between *S. lata*, *S. macraena*, *S.*

lorenziana, and *S. patens*. Of these, *S. lata* is the earliest and seems to be a good representative of the entire group. There are several other names involved in the complex, but it may be as well to use *S. patens* until a comprehensive study of them all can be made.

In our search we have been able to match our figure 28 fairly closely among Schmidt's figures, but we have not found one to correspond with our figure 29 which has prominent markings across the central area.

Stephanopyxis pediastriformis Forti.

(Figures 30, 31, 32.)

Stephanopyxis pediastriformis FORTI, Cont. Diat. XI; Atti, Reale Istituto Veneto, p. 1310 (62). FORTI, Cont. Diat. XIII; Atti del Reale Istituto Veneto di Scienze, Lettere ed Arti, Anno accademico 1912-1913, Tomo LXXII, pt. 2, 1913, pp. 1544-1546 (10-12) pl. 1, figs. 7, 12-17, 19-20. Middle Miocene, Marmorito, Italy.

A species to which we are referring, the one described from the Miocene of Italy, is abundant in the material from the outcrop south of Santiago on the road to Rancho El Refugio, Baja California. It is with some hesitation that this is done although Forti's figures are very good. They do not show the fine dots on the large areolae which are readily resolved on our specimens.

There is considerable doubt as to whether these diatoms should be referred to the genus *Stephanopyxis*, the type species of which is *Pyxidicula* (*Stephanopyxis*) *aculeata* Ehrenberg (1844, p. 264; 1854, pl. 18, fig. 124), selected by Boyer (1927, p. 35), Ehrenberg's 1854 figure, upon which the

FIGURE 28. *Surirella patens* Schmidt. Hypotype no. 3684 (CAS). Length, 0.1920 mm.

FIGURE 29. *Surirella patens* Schmidt. Hypotype no. 3685 (CAS). Length, 0.1640 mm.

FIGURE 30. *Stephanodiscus pediastriformis* Forti. Hypotype no. 3686 (CAS). Diameter, 0.0632 mm., abnormal specimen.

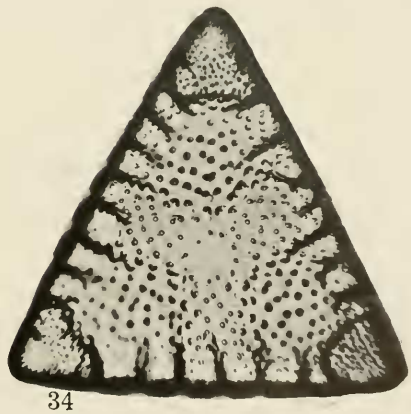
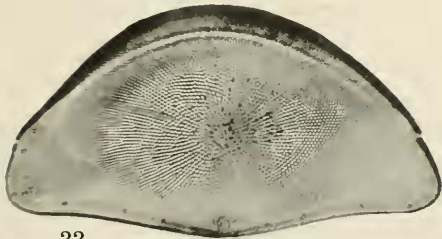
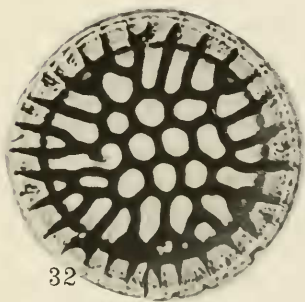
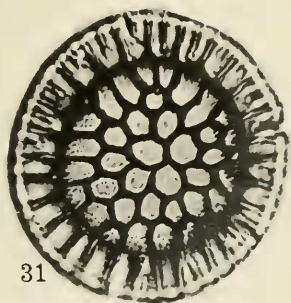
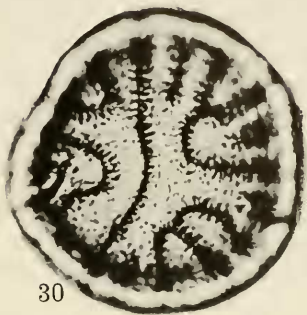
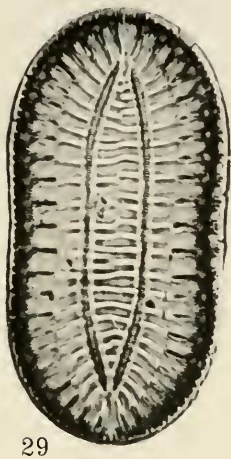
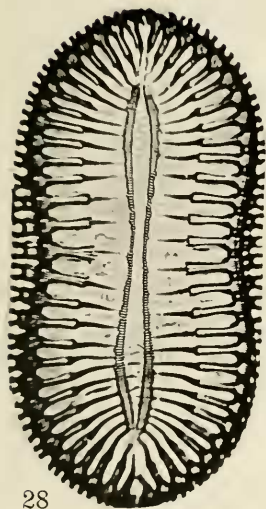
FIGURE 31. *Stephanodiscus pediastriformis* Forti. Hypotype no. 3687 (CAS). Diameter, 0.0752 mm.

FIGURE 32. *Stephanodiscus pediastriformis* Forti. Hypotype no. 3688 (CAS). Diameter, 0.060 mm.

FIGURE 33. *Hemidiscus cuneiformis* Wallich. Hypotype no. 3689 (CAS). Length, 0.1656 mm.

FIGURE 34. *Triceratium tabellarium* Brightwell. Hypotype no. 3690 (CAS). Length of one side 0.1584 mm.

Specimens represented by figures 28-34 are from locality no. 39301 (CAS), eight kilometers south of Santiago, Baja California, and are deposited in the type collection of the Department of Geology of the California Academy of Sciences.



species and genus must be based, unless officially ruled otherwise, is not very satisfactory as Grunow pointed out (1884, pp. 34-40). *Dictyopyxis*, *Peristephania*, and *Systephania* are best considered to be synonyms although the first has priority of two pages over *Stephanopyxis*.

For the present we consider figure 30 to represent an abnormal specimen of *S. pediatriformis*. It may not be possible to separate these diatoms with the very large aerolae from those which have smaller markings. Several names are involved and until an analytic study of the entire genus is made it seems best to identify our specimens with well reproduced illustrations.

Hemidiscus cuneiformis Wallich.

(Figure 33.)

Hemidiscus cuneiformis WALLICH, 1860. Trans. Micr. Soc. London, vol. 8, n.s., p. 42, pl. 2, figs. 3, 4. HUSTEDT, 1930, Kieselalgen, vol. 7, pl. 5, p. 904, fig. 542, a-h.

This is a fairly common diatom in the Santiago, Baja California, deposit. It has received many names, but probably very few can be considered to be distinguishable. Two, *H. nivalis* and *H. simplicissimus*, were described as new from the deposit on Maria Madre Island, Mexico, on the basis of sculpture and largely through lack of literature as well as comparative material. It seems likely that they would be better kept with *H. cuneiformis*.

Triceratium tabellarium (Brightwell).

(Figure 34.)

Triceratium tabellarium BRIGHTWELL, 1856. Quart. Journ. Micr. Sci., p. 275, pl. 17, fig. 15. SCHMIDT, Atlas Diat., pl. 77, 1882, figs. 1, 2. WOLLE, Diat. N. Amer., 1894, pl. 100, fig. 1.

Biddulphia riedyi HANNA AND GRANT, 1926. Proc. Calif. Acad. Sci., ser. 4, vol. 15, p. 132, pl. 14, fig. 6. Maria Madre Island, Mexico.

If minor variation be overlooked, this is one of the most distinctive and common of the tricerati. There are several synonyms. The species is common in the sample studied. Oddly enough, no other species of this genus was found after a reasonable amount of search of well cleaned and segregated material.

Navicula variolata Cleve.

(Figures 35, 37.)

Navicula variolata CLEVE, 1892. Le Diatomiste, vol. 1, p. 76, pl. 12, fig. 7. "Oamaru," New Zealand.

Schmidt (pl. 174, 1892, fig. 26) illustrated a diatom under the name *Navicula variolata* Cleve and which was stated to have come from "Oamaru"

[New Zealand]. Our specimens bear a close resemblance to that figure. Although it may be doubted that an upper Miocene *Navicula* in Baja California would be the same species as one from Oligocene or upper Eocene halfway around the world, we leave the identification that way for want of a better one.

***Navicula hennedyi* Smith.**

(Figures 36, 38, 40, 42.)

Navicula hennedyi SMITH, Syn. British Diat., vol. 2, 1856, p. 93. SCHMIDT, Atlas Diat., pl. 3, 1874, figs. 17, 18.

We group under the name *N. hennedyi* diatoms having a general lyrate marking in the center which is more or less swollen. In *N. lyra* the width of this line is fairly uniform until near the ends.

***Navicula californica* Greville.**

(Figure 39.)

Navicula californica GREVILLE, New Phil. Journ., vol. 10, n.s., 1859, p. 29, pl. 4, fig. 5. SCHMIDT, Atlas Diat., pl. 3, 1874, fig. 16. WOLLE, Diat. N. Amer., 1894, pl. 14, fig. 17.

Navicula stippi HANNA AND GRANT, 1926. Proc. Calif. Acad. Sci., ser. 4, vol. 15, no. 2, p. 156, pl. 17, fig. 12. Maria Madre Island, Mexico.

This species was described from material sent to England about the middle of the last century from the deposit at Monterey, California, It, and many other species were recorded from "Monterey Stone" and this has since been determined to be very close to the upper boundary of the Miocene. This part has been named the "Del Montian Stage" by Robert Kleinpell and was based upon a thorough study of Foraminifera. The species is not as common in the Baja California samples as are some of the other members of the genus. There are other synonyms besides the one listed above.

***Navicula spectabilis* Gregory.**

(Figure 41.)

Navicula spectabilis GREGORY, Trans. Roy. Soc. Edinburgh, vol. 21, pt. 4, 1857, p. 9, pl. 1, fig. 10. SCHMIDT, Atlas Diat., pl. 3, 1874, figs. 20, 21. HANNA AND GRANT, 1926. Proc. Calif. Acad. Sci., ser. 4, vol. 15, no. 2, p. 156, pl. 19, fig. 2. Maria Madre Island, Mexico.

This is another of a group of *Navicula*, the members of which are far from uniform in shape or surface markings. This has led to a very large number of names both binomial and polynomial. The chief distinguishing feature of the specimens which we have referred to the name consists of the central inward projecting of the lateral, heavily striated zones.

Navicula praetexta (Ehrenberg).

(Figures 43, 44.)

Pinnularia (*Mononeis*) *praetexta* EHRENBURG, Monatsber. Akad. Wiss. Berlin, 1844, p. 62, 73 ff.*Pinnularia praetexta* EHRENBURG, Mikogeol, 1854, pl. 19, fig. 28. "Thon aus Aegina." Greece.*Navicula praetexta* (Ehrenberg), GREGORY, 1857. Trans. Roy. Soc. Edinburgh, vol. 21, pt. 4, pp. 9-12, pl. 1, fig. 11. HANNA AND GRANT, 1926. Proc. Calif. Acad. Sci., vol. 15, no. 2, p. 154, pl. 18, figs. 10, 11, 12. Maria Madre Island, Mexico.

In a long discussion of this species, Gregory was led to believe that the locality from which Ehrenberg's material came, was the most ancient record of diatoms at that time. He considered the Aegina deposit to be Eocene or possibly Cretaceous and since his own specimens were living in the Firth of Clyde, he was inclined to believe that all diatom species were still living. Our specimens agree very well with Gregory's figure. The species has been recorded many times from western North America.

Navicula lyra Ehrenberg.

(Figure 45.)

Pinnularia lyra EHRENBURG, Monatsber, Akad. Wiss. Berlin, 1845, p. 315.*Navicula lyra* (Ehrenberg), GREGORY, 1857. Trans. Roy. Soc. Edinburgh, vol. 21, pt. 4, p. 14, pl. 1, figs. 14, 14b. HANNA AND GRANT, 1926. Proc. Calif. Acad. Sci., ser. 4, vol. 15, no. 2, p. 152, pl. 18, fig. 5. Maria Madre Island, Mexico.

FIGURE 35. *Navicula variolata* Cleve. Hypotype no. 3691 (CAS). Length, 0.1300 mm.

FIGURE 36. *Navicula hennedyi* Smith. Hypotype no. 3692 (CAS). Length, 0.0844 mm.

FIGURE 37. *Navicula variolata* Cleve. Hypotype no. 3693 (CAS). Length, 0.1240 mm.

FIGURE 38. *Navicula hennedyi* Smith. Hypotype no. 3694 (CAS). Length, 0.1112 mm.

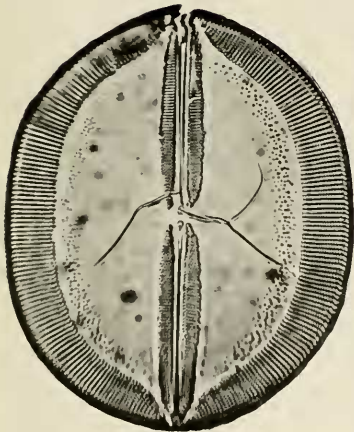
FIGURE 39. *Navicula californica* Greville. Hypotype no. 3695 (CAS). Length, 0.1065 mm.

FIGURE 40. *Navicula hennedyi* Smith. Hypotype no. 3696 (CAS). Length, 0.1392 mm.

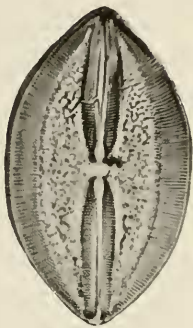
FIGURE 41. *Navicula spectabilis* Gregory. Hypotype no. 3697 (CAS). Length, 0.1168 mm.

FIGURE 42. *Navicula hennedyi* Smith. Hypotype no. 3698 (CAS). Length, 0.1168 mm.

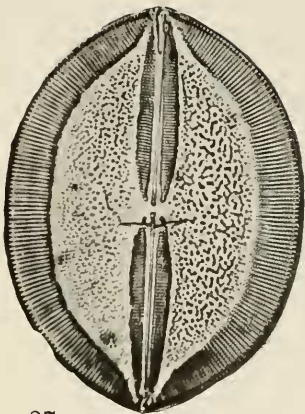
Specimens represented by figures 35-42 are from locality no. 39301 (CAS), eight kilometers south of Santiago, Baja California, and are deposited in the type collection of the Department of Geology of the California Academy of Sciences.



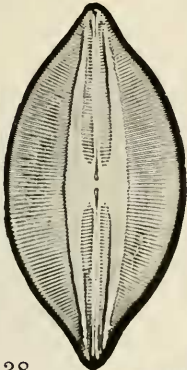
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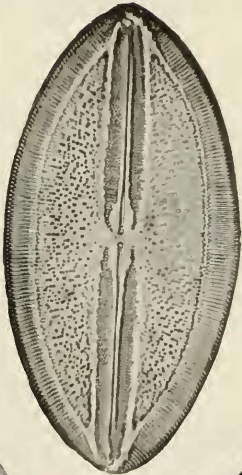
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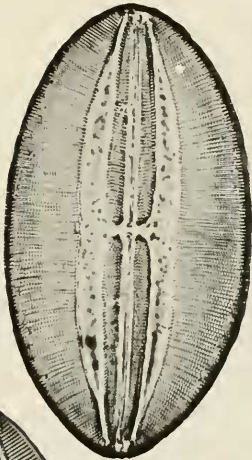
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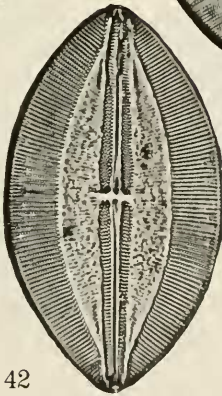
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Many minor variations of this species have received names but it is believed that they serve no useful purpose except to show how many forms it may take. It was fairly common in the Baja California samples.

Navicula clavata Gregory.

(Figure 46.)

Navicula clavata GREGORY, 1856. Trans. Micr. Soc. London, n.s., vol. 4, p. 46, pl. 5, fig. 17. SCHMIDT, Atlas Diat., pl. 3, 1874, fig. 13; pl. 70, 1881, fig. 50; pl. 129, 1888, fig. 16. HANNA AND GRANT, 1926. Proc. Calif. Acad. Sci., ser. 4, vol. 15, no. 2, p. 140, pl. 17, fig. 7. Maria Madre Island, Mexico.

Only a few specimens were found in the Santiago, Baja California, deposit which come close to the figures cited above. Its characters place it between *N. lyra* and *N. hennedyi* as Mann (1907, p. 340) pointed out. If, as seems likely, the number of nominal species in this group of *Navicula* is reduced, then forms such as *clavata* will probably be placed in *Navicula lyra*.

Diploneis crabro Ehrenberg.

(Figures 47, 48.)

Pinnularia (Diploneis) crabro EHRENBURG, Monatsber. Akad. Wiss. Berlin, 1844, p. 85. "Thon aus Aegina." Greece.

Diploneis crabro EHRENBURG, Mikrogeologie, 1854, pl. 19, fig. 29, a, b, c. HENDEY, Journ. Roy. Micr. Soc., vol. 71, 1951, p. 59, pl. 16, fig. 13.

FIGURE 43. *Navicula praetexta* Ehrenberg. Hypotype no. 3699 (CAS). Length, 0.1580 mm.

FIGURE 44. *Navicula praetexta* Ehrenberg. Hypotype no. 3700 (CAS). Length, 0.1256 mm.

FIGURE 45. *Navicula lyra* Ehrenberg. Hypotype no. 3701 (CAS). Length, 0.1360 mm.

FIGURE 46. *Navicula clavata* Gregory. Hypotype no. 3702 (CAS). Length, 0.0856 mm.

FIGURE 47. *Diploneis crabro* Ehrenberg. Hypotype no. 3703 (CAS). Length, 0.170 mm.

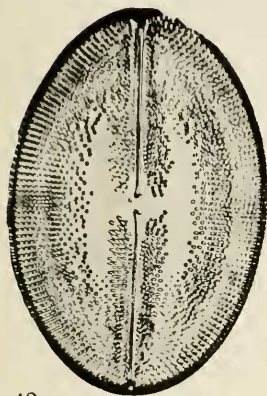
FIGURE 48. *Diploneis crabro* Ehrenberg. Hypotype no. 3704 (CAS). Length, 0.1360 mm.

FIGURE 49. *Diploneis densistriata* Schmidt. Hypotype no. 3705 (CAS). Length, 0.108 mm.

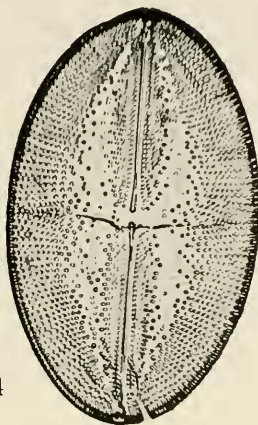
FIGURE 50. *Plagiogramma validum* Greville. Hypotype no. 3706 (CAS). Length, 0.140 mm.

FIGURE 51. *Plagiogramma tessellatum* Greville. Hypotype no. 3707 (CAS). Length, 0.1720 mm.

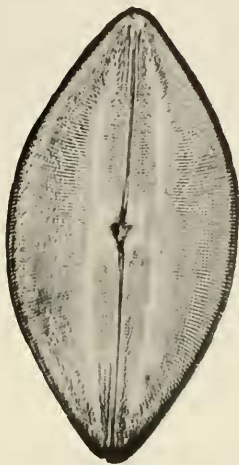
Specimens represented by figures 43-51 are from locality no. 39301 (CAS), eight kilometers south of Santiago, Baja California, and are deposited in the type collection of the Department of Geology of the California Academy of Sciences.



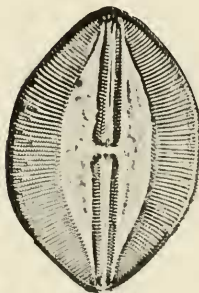
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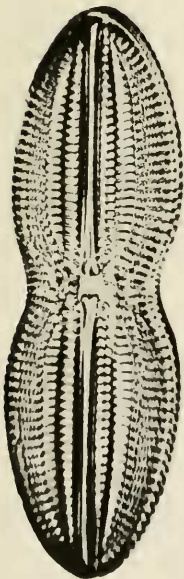
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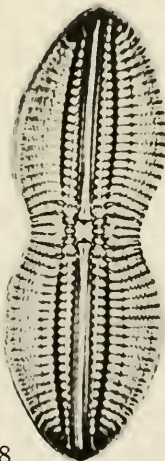
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There is definite need for giving a broad interpretation to species such as this which pass through a multiplicity of minor variations all connected by intermediate individuals.

Diploneis densistriata Schmidt.

(Figure 49.)

Navicula bombus var. *densistriata* SCHMIDT, Atlas Diat., pl. 13, 1875, figs. 11, 12. "California."

Navicula densistriata Schmidt, HANNA AND GRANT, 1926. Proc. Calif. Acad. Sci., ser. 4, vol. 15, no. 2, p. 150, pl. 17, figs. 8-10. Maria Madre Island, Mexico.

There is certainly reason to doubt if the fineness of the surface markings of Schmidt's figures are sufficiently constant and distinct from what might be considered a typical specimen of *Diploneis bombus*. However, this may be, the specimens we found in the Baja California samples do not differ greatly from those found in the deposit on Maria Madre Island.

Plagiogramma validum Greville.

(Figure 50.)

Plagiogramma validum GREVILLE, 1859. Quart. Journ. Micro. Sci., vol. 7, p. 209, pl. 10, fig. 8. "California Guano." WOLLE, Diat. N. Amer. 1894, pl. 45, figs. 8, 9. California and Campechy Bay, Mexico.

The hyaline area in the center of this species is rectangular, the sides are slightly smaller than in the species *tessellatum* which is also present in the Santiago deposit.

Plagiogramma tessellatum Greville.

(Figure 51.)

Plagiogramma tessellatum GREVILLE, 1859. Quart. Journ. Micr. Sci., vol. 7, p. 208, pl. 10, fig. 7. "California guano." WOLLE, 1894. Diat. N. Amer., pl. 45, figs. 18, 19.

The central hyaline area of this species is usually nearly circular and the sides are not constricted above and below the center as in *P. validum*. The species is rather common in the Santiago deposit.

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